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<b>TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371</b>				<b>U S APPLICATION NO. (If known, see 37 CFR 1.5) 10/089155</b>	
INTERNATIONAL APPLICATION NO <b>PCT/JP00/06711</b>		INTERNATIONAL FILING DATE <b>September 28, 2000</b>		PRIORITY DATE CLAIMED <b>September 28, 1999</b>	
TITLE OF INVENTION <b>MAGNETIC RESONANCE IMAGING DIAGNOSTIC APPARATUS AND METHOD THEREFOR</b>					
APPLICANT(S) FOR DO/EO/US <b>SHIMIZU, HIROMICHI</b>					
Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:					
1. <input checked="" type="checkbox"/> This is a <b>FIRST</b> submission of items concerning a filing under 35 U.S.C. 371.					
2. <input type="checkbox"/> This is a <b>SECOND</b> or <b>SUBSEQUENT</b> submission of items concerning a filing under 35 U.S.C. 371.					
3. <input type="checkbox"/> This express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.					
4. <input checked="" type="checkbox"/> The US has been elected by the expiration of 19 months from the priority date (Article 31).					
5. <input checked="" type="checkbox"/> A copy of the International Application as filed (35 U.S.C. 371(c)(2)) a. <input type="checkbox"/> is transmitted hereto (required only if not communicated by the International Bureau). b. <input checked="" type="checkbox"/> has been communicated by the International Bureau. c. <input type="checkbox"/> is not required, as the application was filed in the United States Receiving Office(RO/US)					
6. <input checked="" type="checkbox"/> An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)). a. <input checked="" type="checkbox"/> is attached hereto. b. <input type="checkbox"/> has been previously submitted under 35 U.S.C. 154(d)(4).					
7. <input type="checkbox"/> Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)) a. <input type="checkbox"/> are attached hereto (required only if not communicated by the International Bureau). b. <input type="checkbox"/> have been communicated by the International Bureau. c. <input type="checkbox"/> have not been made; however, the time limit for making such amendments has NOT expired. d. <input type="checkbox"/> have not been made and will not be made.					
8. <input type="checkbox"/> An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).					
9. <input checked="" type="checkbox"/> An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).					
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<b>Items 11 to 20 below concern document(s) or information included:</b>					
11. <input type="checkbox"/> An Information Disclosure Statement under 37 CFR 1.97 and 1.98.					
12. <input checked="" type="checkbox"/> An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.					
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20. <input checked="" type="checkbox"/> Other items or information: <b>Figs. 1,2a-2d,3-10, Credit Card Payment Form, International Publication Number</b>					
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U.S. APPLICATION NO. (If known, see 37 CFR 1.5)				INTERNATIONAL APPLICATION NO		ATTORNEY'S DOCKET NUMBER																																																																															
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<div>21. The following fees are submitted.</div> <div><b>BASIC NATIONAL FEE (37 CFR 1.492(a) (1) - (5)):</b></div> <div><input type="checkbox"/> Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .....\$1040.00</div> <div><input checked="" type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO .....\$890.00</div> <div><input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO .....\$740.00</div> <div><input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) .....\$710.00</div> <div><input type="checkbox"/> International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) .....\$100.00</div> <div><b>ENTER APPROPRIATE BASIC FEE AMOUNT =</b></div> <div>Surcharge of <b>\$130.00</b> for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(e)).</div> <table border="1" style="width:100%; border-collapse: collapse;"><thead><tr><th style="width:15%;">CLAIMS</th><th style="width:15%;">NUMBER FILED</th><th style="width:15%;">NUMBER EXTRA</th><th style="width:15%;">RATE</th><th style="width:15%;">\$</th><th style="width:15%;"></th></tr></thead><tbody><tr><td>Total Claims</td><td>18 - 20 =</td><td>0</td><td>x \$18.00</td><td>\$</td><td></td></tr><tr><td>Independent Claims</td><td>3 - 3 =</td><td>0</td><td>x \$84.00</td><td>\$</td><td></td></tr><tr><td colspan="3">MULTIPLE DEPENDENT CLAIMS(S) (if applicable) 280</td><td>+ \$280.00</td><td>\$280.00</td><td></td></tr><tr><td colspan="4"><b>TOTAL OF ABOVE CALCULATIONS =</b></td><td>\$1,170.00</td><td></td></tr><tr><td colspan="4"><input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.</td><td>\$</td><td></td></tr><tr><td colspan="4"><b>SUBTOTAL =</b></td><td>\$</td><td></td></tr><tr><td colspan="4">Processing fee of <b>\$130.00</b> for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).</td><td>\$</td><td></td></tr><tr><td colspan="4"><b>TOTAL NATIONAL FEE =</b></td><td>\$1,170.00</td><td></td></tr><tr><td colspan="4">Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) <b>\$40.00</b> per property</td><td>\$40.00</td><td></td></tr><tr><td colspan="4"><b>TOTAL FEES ENCLOSED =</b></td><td>\$1,210.00</td><td></td></tr><tr><td colspan="4"></td><td style="text-align: right;">Amount to be refunded:</td><td>\$</td></tr><tr><td colspan="4"></td><td style="text-align: right;">charged:</td><td>\$</td></tr></tbody></table>						CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE	\$		Total Claims	18 - 20 =	0	x \$18.00	\$		Independent Claims	3 - 3 =	0	x \$84.00	\$		MULTIPLE DEPENDENT CLAIMS(S) (if applicable) 280			+ \$280.00	\$280.00		<b>TOTAL OF ABOVE CALCULATIONS =</b>				\$1,170.00		<input type="checkbox"/> Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.				\$		<b>SUBTOTAL =</b>				\$		Processing fee of <b>\$130.00</b> for furnishing the oath or declaration later than <input type="checkbox"/> 20 <input type="checkbox"/> 30 months from the earliest claimed priority date (37 CFR 1.492(f)).				\$		<b>TOTAL NATIONAL FEE =</b>				\$1,170.00		Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) <b>\$40.00</b> per property				\$40.00		<b>TOTAL FEES ENCLOSED =</b>				\$1,210.00						Amount to be refunded:	\$					charged:	\$	CALCULATIONS PTO USE ONLY	
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<div>a. <input type="checkbox"/> A check in the amount of \$_____ to cover the fees is enclosed.</div> <div>b. <input type="checkbox"/> Please charge my Deposit Account No <u>01-2135</u> in the amount of \$_____ to cover the above fees. A duplicate copy of this sheet is enclosed</div> <div>c. <input checked="" type="checkbox"/> The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No <u>01-2135</u>. A duplicate copy of this sheet is enclosed</div> <div>d. <input checked="" type="checkbox"/> Fees are to be charged to a credit card <b>WARNING:</b> Information on this form may become public. <b>Credit card information should not be included on this form.</b> Provide credit card information and authorization on PTO-2038.</div> <div><b>NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.</b></div> <div>SEND ALL CORRESPONDENCE TO:</div> <div><b>Antonelli, Terry, Stout &amp; Kraus, LLP</b> 1300 North Seventeenth Street Suite 1800 Arlington, VA 22209 USA</div>						<div> SIGNATURE</div> <div><b>Melvin Kraus</b> NAME</div> <div><b>22,466</b> REGISTRATION NO.</div>																																																																															

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## MAGNETIC RESONANCE IMAGING DIAGNOSTIC APPARATUS AND METHOD THEREFOR

### FIELD OF THE INVENTION

The present invention relates to a magnetic resonance imaging diagnostic apparatus (hereinafter this is referred to MRI apparatus), particularly to an MRI apparatus having a spectroscopic imaging function.

### BACKGROUND OF THE ART

A spectroscopic imaging method using a magnetic resonance diagnostic apparatus for medical use (MRI) (hereinafter, this is referred to MRSI method) is a method for imaging a distribution of specific chemical component in the living body. This method can acquire not only an anatomical information, which is acquired in an ordinary MRI, but also can acquire a chemical information of carbohydrate metabolism or an energy metabolism or the like. So it is useful for diagnosis at first stage of disease.

Various kind of MRSI methods are attempted such as 3D-CSI method for measuring a chemical shift as a temporal coefficient, but a method using proton ( $^1\text{H}$  nucleus) is generally used in an MRI apparatus for a clinical use. 3D-CSI method includes phase encoding of a spatial information in direction x and y, and a spectrum information is encoded with time progress in a signal measurement.

In MRSI to measure proton, signals of water and fat disturb because they are included in the living body more than 2 to 4 orders in comparison with metabolic materials. So it is necessary to combine a technique to suppress them. Prior art will be described referring to Fig. 9 and Fig. 10. In the prior art, the spectrum of water is selectively excited in preprocessing by CHESS pulse 31, subsequently gradient magnetic field 33 is applied to dephase a magnetization of water so as not to produce signal. Furthermore, after having excited the slice perpendicular to the imaging section (fat part) with pulse 32, gradient magnetic field 34 is applied to dephase this magnetization in this slice (OVS : Outer Volume Suppression). This process is repeated to cover all of fat region with changing slice. After this preprocessing is completed, a spectroscopic imaging is performed.

An example will be described using a transaxial slice of head in Fig.9. Excitation and dephasing are performed from slice 1 to 8 with changing the



That is to say, an MRI apparatus of the present invention comprises magnetic field generation means for generating static magnetic field, gradient magnetic field and high frequency magnetic field (RF) to the object to be examined respectively, and detection means for detecting an magnetic resonance signal generated from the object to be examined, and image reconstruction means for image reconstructing with an magnetic resonance signal detected, and display means for displaying a reconstructed image, and control means for controlling said each means.

Control means comprises means for setting a desired region of interest (ROI) in a predetermined region of the object, and means for calculating modulation wave form of RF excited selectively in this ROI. And control means performs controlling the application of an RF pulse modulated with modulation wave form and swing gradient magnetic field of the direction of two or three axes simultaneously, and acquires signals including a spectrum information about the predetermined region of the object.

Only the interior of ROI with an arbitrary shape being looked at is excited and the signal is acquired. So effect of fat and water from the exterior of ROI can be effectively suppressed. Thus fixed quantity of spectrum can be improved and accuracy of diagnosis can be improved. In addition, the excitation pulse is selective in region, so it is no need to irradiate fat suppression RF pulse in preprocessing for performing phase encode repeatedly. So time for preprocessing can be shortened. As a result recovery of water signal can be reduced.

In the MRI apparatus of the present invention, means for setting ROI displays a slice image obtained at desired slice position as a scout image, and function to set ROI on the scout image displayed is interactively.

Means for calculating an RF waveform concretely makes an excitation form function from the shape of ROI, and calculates a modulated waveform of high frequency magnetic field by two-dimensional Fourier transformation of this excitation form function in nearly real time.

This RF waveform for selective excitation is different from the shape of ROI. But by previously imaging a scout image and displaying it, ROI is able to set interactively on this scout image. Accordingly an arbitrary ROI shape can be easily set. In addition, a modulated RF waveform is generated by performing two-dimensional Fourier transformation with computer to the shape of set ROI. So an RF waveform corresponding to ROI can be acquired

with nearly real time. And an MRSI measurement can be performed soon after setting of ROI.

Moreover a preferred embodiment of an MRI apparatus in the present invention, control means sets the smallest rectangular region including ROI, and determines an image matrix size according to this rectangular region.

An image matrix size is the size of image data for expressing the number of pixel (or voxel), which is the number of line  $\times$  row, arranged in two-dimensional or three-dimensional. It is defined with the number of gradient magnetic field encode for encoding spatial information. Accordingly, it is no need to make the size of image matrix so large by defining it with the smallest rectangle for covering the shape of ROI. As a result it is no need to repeat useless phase encode. And measurement time of MRSI can be shortened.

#### BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a flow chart showing procedure in the embodiment of the present invention.

Fig.2 is a view showing method of setting ROI interactively, and an matrix.

Fig.3 is a figure showing one example of sequence applied to the present invention.

Fig.4 is a view showing whole composition of MRI apparatus of the present invention.

Fig.5 is a view showing another example of sequence applied to the present invention.

Fig.6 is a flow chart showing procedure according to another embodiment of the present invention.

Fig.7 is a view showing another example of sequence applied to the present invention.

Fig.8 is a view showing another example of sequence applied to the present invention.

Fig.9 is a view showing a traditional fat suppression method.

Fig.10 is a view showing sequence with the combination of water suppression and fat suppression in traditional type.

#### THE BEST MODE FOR CARRYING OUT THE INVENTION

The present invention will be described precisely referring to Fig.1 or Fig.8. Fig. 4 is a schematic block diagram of an MRI apparatus applied to the present invention. This MRI apparatus comprises static magnetic field generating magnetic circuit 402 for generating uniform static magnetic field  $B_0$  in the interior of the object to be examined 401, gradient magnetic field generation system 403 for generating gradient magnetic field  $G_x$ ,  $G_y$ ,  $G_z$  for changing those intensity linearly to three direction  $x$ ,  $y$  and  $z$  being perpendicular to each other, transmitter system 404 for generating high frequency magnetic field, detection system 405 for detecting nuclear magnetic resonance signal generated from the object, signal processing system 406, computer 408 for performing calculation of image reconstruction and controlling the whole apparatus, sequencer 407 for controlling gradient magnetic field generation system 403, transmitter system 404 and detection system 405 with the order from computer 408, operation part 421 for sending necessary order to signal processing system 406 and computer 408.

Static magnetic field generation magnetic circuit 402 comprises an electromagnet or a permanent magnet. And the object 401 is accommodated in the space of its static magnetic field.

Gradient magnetic field generation system 403 comprises gradient magnetic field coil 409 with three axes, power supply 410 for supplying current to the gradient magnetic field coil. And it generates a linear gradient magnetic field for applying spatial information to the magnetic resonance signal and swing gradient magnetic field when ROI is selectively excited.

Transmitter system 404 comprises synthesizer 414 for generating predetermined high frequency pulses, modulator 412 for modulating high frequency pulse generated from synthesizer 411, electric power amplifier 413, and transmitter coil 414 a. Modulation wave form modulated by this modulator 412 is calculated and saved by computer 408 as the following procedure and given from sequencer 407. High frequency magnetic field is generated in the interior of the object 401 to excite a nuclear spin, by supplying high frequency pulse modulated with predetermined modulation waveform to transmitter coil 414a. An excited nuclear spin is usually use  $^1\text{H}$ . But other nuclear such as  $^{31}\text{P}$ ,  $^{12}\text{C}$  or the like are also used.

Detection system 405 comprises receiver coil 414b for receiving nuclear magnetic resonance signals emitted from the object 401, amplifier 415, quadrature phase detector 416, and A / D converter 417. Nuclear





region is set with mouse or the like so as to cover the desired region entirely without covering fat (step 12). Fig.2 is a view showing typically the scout image displayed, and 61 is an ROI input with mouse.

Thus after smoothing set ROI 61, 2 value function of interior of ROI being 1 and exterior of ROI being 0 are made to define form function  $D(x,y)$  (step 13). The shape of ROI can be specified with an arbitrary shape principally. However, the shape is more complex, the Fourier transformation  $D'(kx,ky)$  of form function  $D(x,y)$  includes more high frequency components that is the edge of k space component. So it is necessary to enlarge k space in the imaging after that. This means that amplitude of swing gradient magnetic field is large, and its application time is long. In this case it is difficult to equipment and imaging time has to be expanded. Accordingly, in inputting the shape of ROI, it is more practical to avoid making complex unnecessarily. In addition, the borderline of form function changes more sharply in rising up, fat region is suppressed sharply. But it is severe in amplitude characteristic and transient characteristic of gradient magnetic field. It is preferable to apply smoothing for 2 value function  $D(x, y)$  necessarily. For example, on the borderline of the value D changing from 0 to 1, it has a certain amount of width to decrease gradually from 1 to 0.

Next two dimensional Fourier transformation is performed on form function  $D(x,y)$  to generate function  $D'(kx,ky)$  of k space. By using this function  $D'$ , RF waveform  $B_1(t)$  is calculated with an equation (1) (step 14).

$$B_1(t) = D'(k_x(t), k_y(t)) \cdot |\gamma G(t)| \quad \dots(1)$$

Gradient magnetic field waveform  $G_x(t)$ ,  $G_y(t)$  are predetermined to a imaging sequence of the imaging. For example, gradient magnetic field waveform  $G_x(t)$ ,  $G_y(t)$  having the shape of spiral orbit converging from the edge of k space to start point with constant speed can be used. Specific example of these gradient magnetic field waveform  $G_x(t)$ ,  $G_y(t)$  are shown in equation (2). These are sine wave or cosine wave, in which their amplitudes decrease linearly as a function of time.

$$G_x(t) = -A/\gamma T [2\pi n(1 - t/T)\sin 2\pi nt/T + \cos 2\pi nt/T] \quad \dots(2)$$

$$G_y(t) = A/\gamma T [2\pi n(1 - t/T)\cos 2\pi nt/T - \sin 2\pi nt/T]$$

In an equation (2),  $T/n$  is a rotation period of spiral of said space. In addition,  $A$  is a fixed number for defining size of spiral.  $n$  is usually about 10.

In addition, gradient magnetic field waveform  $G_x(t)$ ,  $G_y(t)$  is preferable to cover their orbit uniformly to the  $k$  space. Not only spiral, but also zigzag orbit such as used in EPI method can be used.

The RF waveform  $B_1(t)$  calculated from these steps is saved to memory. And proceeding process is finished. Subsequently MRSI is performed by using RF excitation pulse modulated with this RF waveform  $B_1(t)$  (step 15). In this step, amplitude of RF waveform  $B_1(t)$  is arranged experimentally such that the maximum flip angle is  $90^\circ$ .

One embodiment of an MRSI imaging sequence of the present invention will be shown in Fig. 3. In this imaging sequence the spatial selective excitation is applied to 3D-CSI method. At first excitation pulse 71 is applied together with gradient magnetic field 74, 75 swinging to the  $x$  and  $y$  direction. And only the magnetization in the interior of two-dimensional region of the  $x$ - $y$  plane is excited. Slice selective gradient magnetic field  $G_z$  is not applied in this case. The interior of ROI with nearly the shape of  $D(x,y)$  is excited with this excitation pulse. Accuracy of excitation form depends on the amount of high frequency component included in gradient magnetic field 74, 75 at  $k$ -space. Subsequently a spatial information of  $x$ ,  $y$  is encoded to phase of magnetization by phase encode gradient magnetic field 76, 77. Refocus pulse 72 is applied together with slice selective gradient magnetic field  $G_z$  73 to generate echo 78 after TE interval from the excitation. Thus the generated echo is received as a signal.

And waiting the recovery of longitudinal magnetization, next cycle is performed to repeat signal measurement with changing the phase encode amount. Three-dimensional Fourier transformation is performed to acquired echo signal as a function of phase encode ( $k_x, k_y$ ) and time  $t$  to obtain a spectroscopic image (metabolic distribution image). In addition, it is desirable for MRSI method to use spin echo type as shown in the figure. Generally when frequency of excitation pulse is offset from resonance frequency, shape of an excited region and phase of transverse magnetization is affected with this offset. But in case of application of spin echo type, an influence by this offset is canceled by application of refocus  $180^\circ$  pulse 72.

The reconstructed image of metabolic distribution can be displayed to



In the normal 3D-CSI method, phase encode step is usually performed with  $16 \times 16$  or  $32 \times 32$ . As shown in 63 of Fig.3, its field of view is square. But in this embodiment, the image matrix is set corresponding to the smallest rectangular region 62 covering ROI. Accordingly it is no need to measure exterior pixels where magnetization is not excited, and repetition time of phase loop can be reduced. In addition, as shown in Fig.2 (c) and (d), it is preferable to rotate the direction of coordinate axis of image measuring matrix in accordance with inclination of ROI 61 that is the direction of rectangle. Thus region along the shape of ROI can be set, so it is possible to get the minimum number of repetition step. The others are the same as the embodiment shown in Fig.1.

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encode loop 91 in the slice direction is added to it. In addition, gradient magnetic field in the slice direction applied at the same time with refocus pulse 72 is slab selective gradient magnetic field, and it can be omitted.

In this three-dimensional MRSI also, the scout image is imaged in preprocessing, and ROI is set on the scout image. And the RF waveform is calculated from this shape function in the same way. And the image matrix size can be determined in the direction of x and y in accordance with the set ROI.

In addition, in the above-mentioned embodiment, spin echo type MRSI is described. And it is described that spin echo type is preferable for removing influence of offset to resonance frequency. But in case of measuring material with short T2, it is possible to apply with FID type.

This example will be shown in Fig. 8. In Fig.8, after the application of RF excitation pulse 71, phase encode magnetic field 76, 77 are applied in a short time. Then FID signal is measured immediately.

As thus described, MRSI with spatial selective excitation is described by using 3D-CSI method as an example. And spatial selective excitation can be performed with MRSI sequence by using another sequence such as EPI, FSE or the like.

According to the present invention described above, necessary part can be excited to obtain a signal with avoiding unnecessary part such as fat. Then metabolic image can be obtained for precisely excluding fat signals. In addition, as a result of no need to suppress fat in OVS of the preprocessing at each phase encoding. Accordingly the preprocessing can be shortened. And recovery of water due to longitudinal relaxation can be reduced. In addition, desired ROI is set interactively on a scout image to calculate automatically the RF excitation waveform from the ROI shape with calculator. And MRSI is performed soon after ROI is set. Furthermore, a minimum rectangular matrix is set in accordance with ROI to reduce useless measuring loop of MRSI. Then speedup of MRSI can be achieved.

These preferred embodiments of the present invention have been described referring to figures. It will be easily understood that the present invention can be varied without departing from the scope of the invention.

## CLAIMS

1. Magnetic resonance imaging diagnostic apparatus comprising;  
     magnetic field generation means for generating static magnetic field, gradient magnetic field and high frequency magnetic field (RF) to said object to be examined respectively,  
     detection means for detecting magnetic resonance signal generated from said object,  
     image reconstruction means for image reconstructing said detected magnetic resonance signal,  
     display means for displaying said reconstructed image, and  
     control means for controlling said each means,  
     in which said magnetic field generation means generates gradient magnetic field to three directions being perpendicular to each other, and said control means applies swinging gradient magnetic field with predetermined amplitude at least two directions at the same time applying said high frequency magnetic field.
2. Magnetic resonance imaging diagnostic apparatus according to claim 1, wherein said control means includes means for setting region of interest (ROI) in predetermined region, and applies high frequency magnetic field for selectively exciting to said region of interest.
3. Magnetic resonance imaging diagnostic apparatus according to claim 1, wherein said control means controls to perform predetermined modulation to said high frequency magnetic field.
4. Magnetic resonance imaging diagnostic apparatus according to anyone of claim 1 to 3, wherein said control means applies high frequency magnetic field for selectively exciting water spectrum before applying said swing gradient magnetic field and gradient magnetic field for dephasing magnetization of water.
5. Magnetic resonance imaging diagnostic apparatus according to claim 2,

wherein said ROI setting means sets ROI on a slice image previously imaged and displayed on said display means.

6. Magnetic resonance imaging diagnostic apparatus according to claim 2, wherein said control means applies predetermined modulation based on said form of said ROI to said high frequency magnetic field.

7. Magnetic resonance imaging diagnostic apparatus comprising;

magnetic field generation means for generating static magnetic field, gradient magnetic field and high frequency magnetic field(RF) to said object to be examined respectively,

detection means for detecting magnetic resonance signal generated from said object,

image reconstruction means for image reconstructing said detected magnetic resonance signal,

display means for displaying said reconstructed image, and

control means for controlling said each means,

in which said control means comprises means for setting desired region of interest (ROI) in said predetermined region of said object, and means for calculating modulation wave form of high frequency magnetic field for selectively exciting said set ROI, and performs the control of applying the modulated high frequency magnetic field with said modulation wave form at the same time swing gradient magnetic field of two or three axis direction, and acquiring signal including spectrum information from determined region of said object.

8. Magnetic resonance imaging diagnostic apparatus according to claim 7, wherein said setting of ROI is performed by displaying slice image of desired slice to said display means as a scout image, and setting interactively said RIO on said displayed scout image.

9. Magnetic resonance imaging diagnostic apparatus according to claim 7 or 8, wherein said control means sets a minimum rectangular region for including said ROI, and determines an image matrix size in accordance with this rectangular region.

10. Magnetic resonance imaging diagnostic method for imaging distribution of specified chemical kind, comprising following steps;

- (A) step for applying high frequency magnetic field to excite desired region,
- (B) step for applying swing gradient magnetic field having predetermined amplitude to two of three directions being perpendicular to each other,
- (C) step for applying phase encode gradient magnetic field with changing said intensity along the directions as same as those of swing gradient magnetic field applied at (B),
- (D) step for applying gradient magnetic field for selecting slice in a direction different from that of swing gradient magnetic field applied at (B)
- (E) step for applying high frequency magnetic field to reverse magnetization excited at step (A) at the same time step (D),
- (F) step for detecting echo signal generated after a period, which is the same passing time from application of high frequency magnetic field at step (A) until application of high frequency magnetic field at step (E), after step (E).
- (G) step for image reconstructing signal detected at step (F) and display the image.

11. Magnetic resonance imaging diagnostic method according to claim 10, wherein following step is performed before step (A).

- (H) step for setting ROI in said predetermined region.

12. Magnetic resonance imaging diagnostic method according to claim 10, wherein following step is performed before step (A).

- (I) step for applying modulation to high frequency magnetic field in step (A).

13. Magnetic resonance imaging diagnostic method according to claim 10, wherein following steps are performed before step (A)

- (J) step for applying high frequency magnetic field to selectively excite water spectrum.
- (K) step for applying gradient magnetic field to dephase magnetization of water.

14. Magnetic resonance imaging diagnostic method according to claim 10, wherein following step is performed before step (A)

- (L) step for setting ROI on slice image previously imaged.



15. A magnetic resonance imaging diagnostic method according to claim 14, wherein following step is performed before step (A).  
(M) step for modulating wave form based on the form of the ROI.

## ABSTRACT

A spatial region in an imaged slice is two-dimensionally excited by applying an oscillating gradient magnetic field in two or three axial directions together with RF thus to conduct an MRSI. At a preprocessing step, a scout image is formed, an ROI is interactively set on the image, and an RF modulating waveform is automatically generated by two-dimensional Fourier transformation of an ROI shape, and a measurement matrix for the smallest square covering the ROI is automatically generated. By the MRSI, RF is modulated with the RF modulating waveform generated at the preprocessing step to measure an image matrix formed at the preprocessing step. Since an unnecessary portion such as a fat portion can be avoided precisely along its shape and only necessary portions are excited, a metabolic substance image from which unnecessary signals are completely eliminated can be generated. Since a desired ROI is inputted interactively on a scout image, the ROI can be simply set. The measurement time can be shortened by using a square measurement matrix.

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Fig. 1

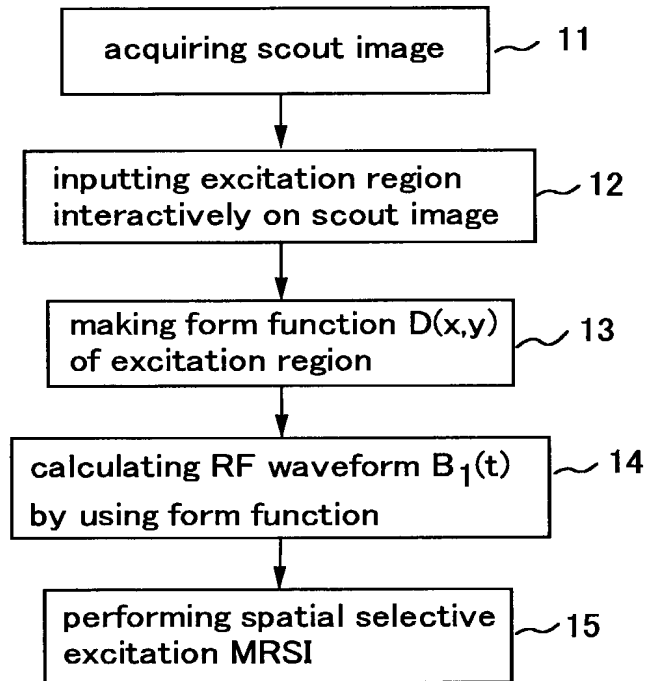




Fig. 3

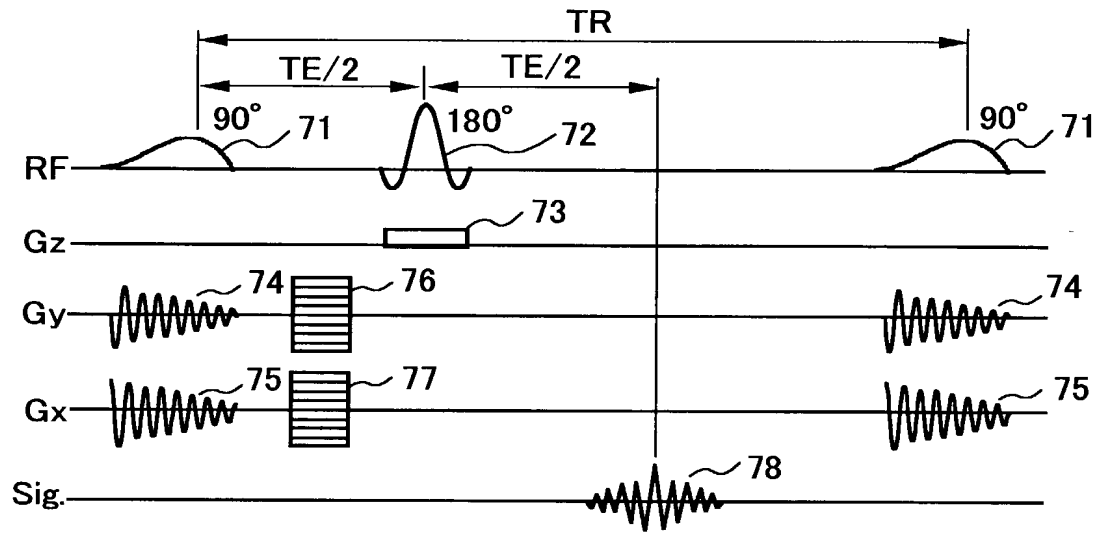
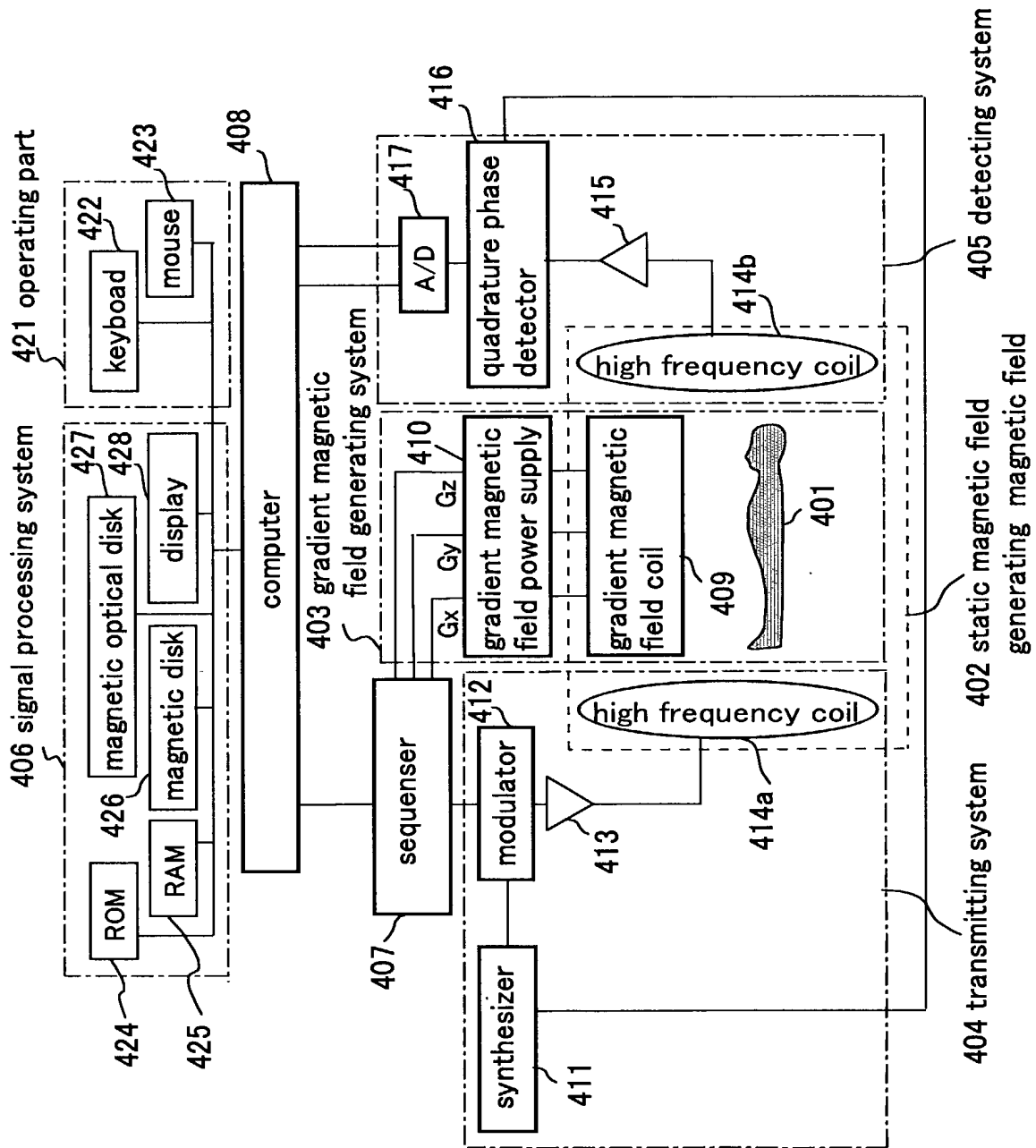


Fig.4



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Fig.5

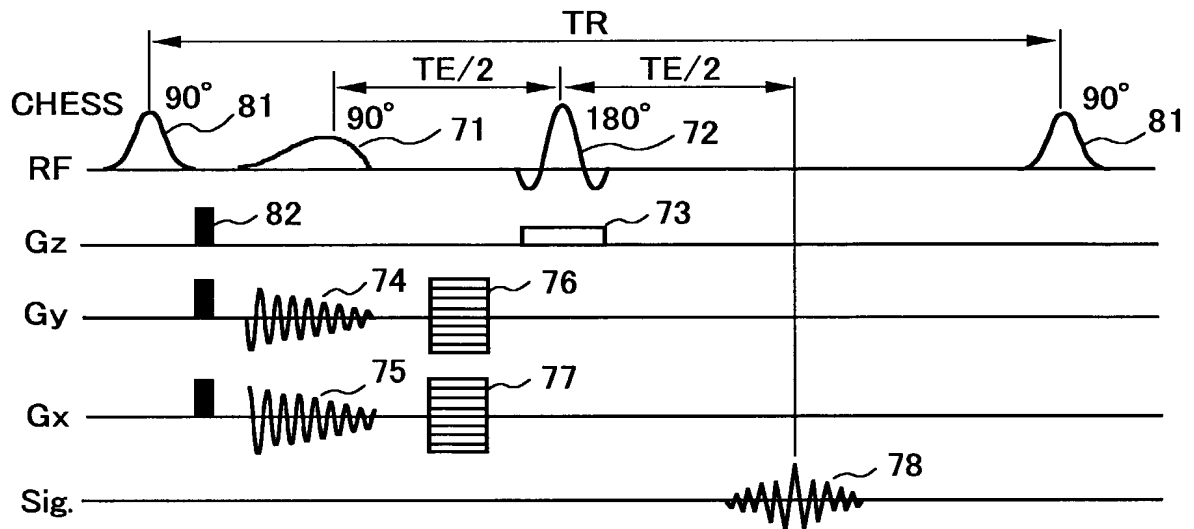
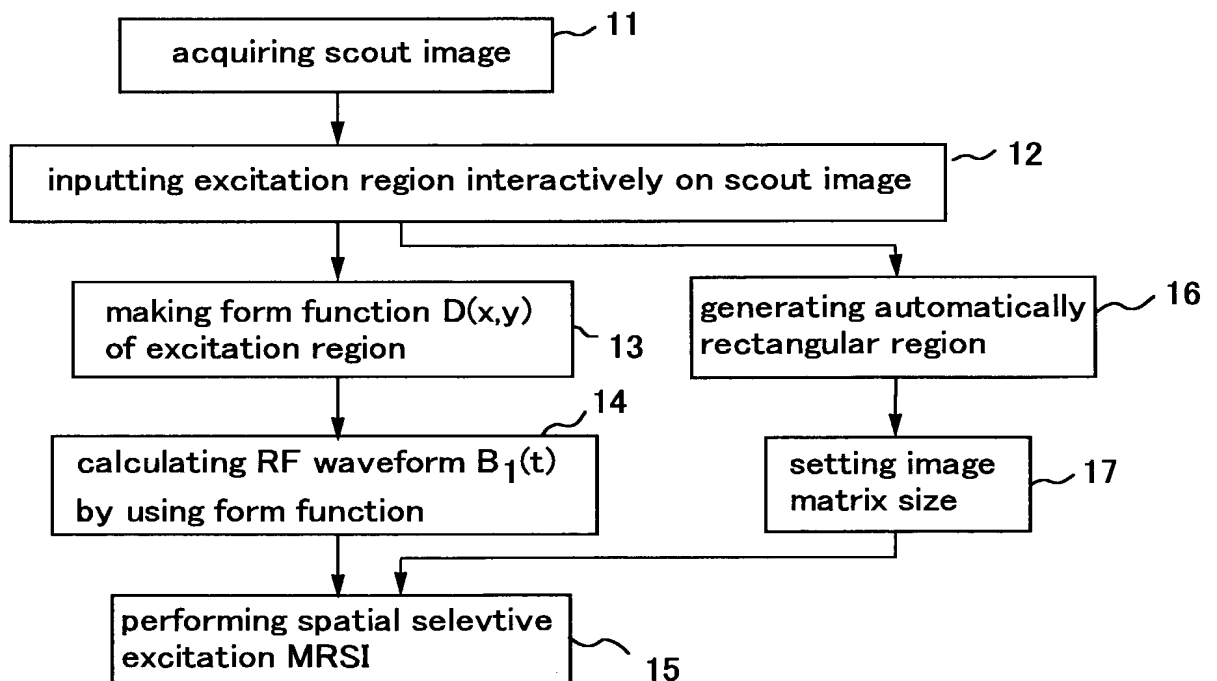


Fig.6



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Fig.7

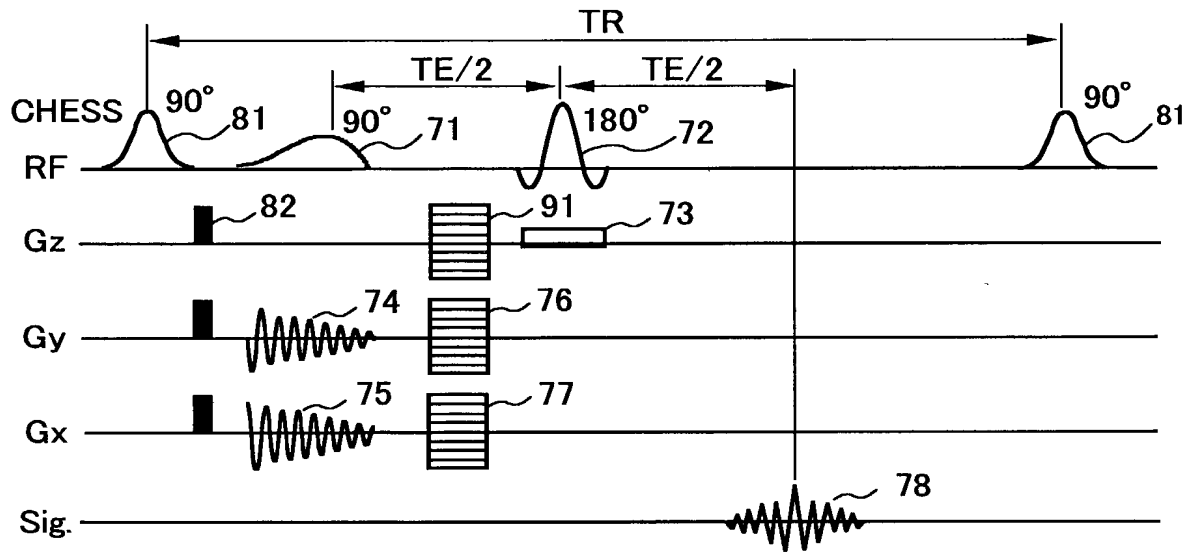
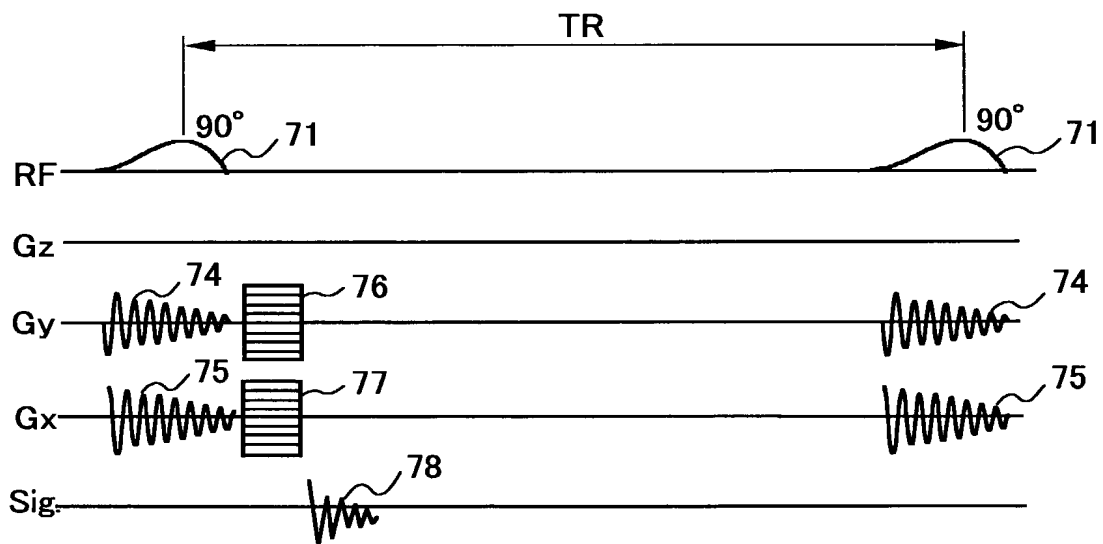
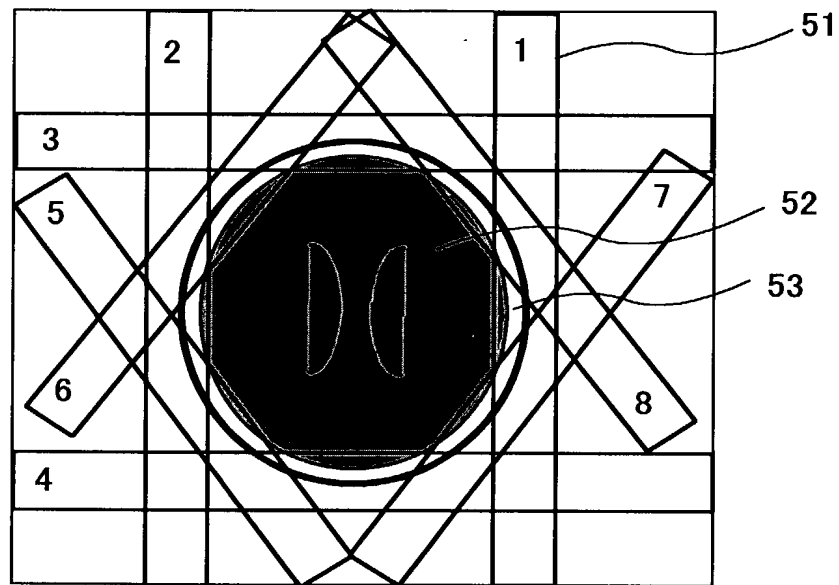


Fig.8

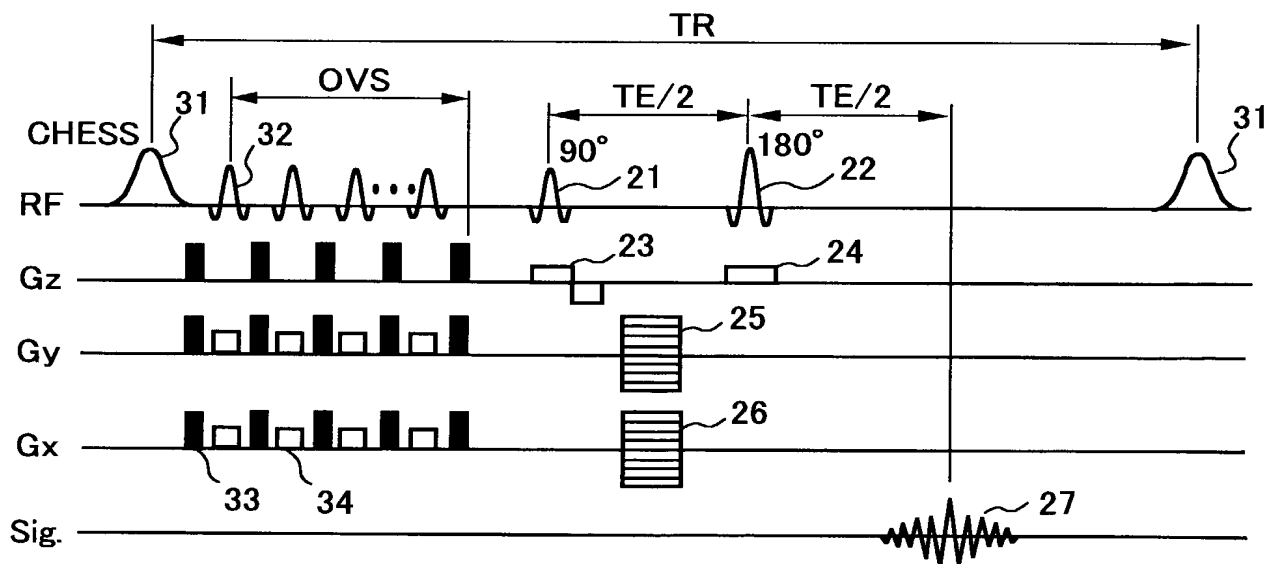




**Fig.9**



**Fig.10**



Attorney's Docket No.: 529.41290X00

**DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION**

As a below named inventor, I hereby declare that: my residence, post office address and country of citizenship are as stated below, next to my name; I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

**MAGNETIC RESONANCE IMAGING DIAGNOSTIC APPARATUS AND METHOD THEREFOR**

the specification of which

\_\_\_\_\_ is attached hereto.

x was filed on September 28, 2000 as

United States Application Number \_\_\_\_\_

or PCT International Application Number PCT/JP00/06711

and was amended on \_\_\_\_\_

(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
<u>11/275286</u>	<u>JP</u>	<u>28/September/1999</u>	<u>X</u>	_____
(Number)	(Country)	(Day/Month/Year Filed)	Yes	No
_____	_____	_____	Yes	No
(Number)	(Country)	(Day/Month/Year Filed)		

I hereby claim the benefit under title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below

_____	_____
(Application Number)	Filing Date

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

_____	_____	_____
(Application Number)	Filing Date	(Status -- patented, pending, abandoned)

I hereby appoint: Donald R. Antonelli, Reg. No. 20,296; Melvin Kraus, Reg. No. 22,466; William I. Solomon, Reg. No. 28,565; Gregory E. Montone, Reg. No. 28,141; Ronald J. Shore, Reg. No. 28,577; Donald E. Stout, Reg. No. 26,422; Alan E. Schiavelli, Reg. No. 32,087; James N. Dresser, Reg. No. 22,973; Carl I. Brundidge, Reg. No. 29,621; Paul J. Skwierawski, Reg. No. 32,173; and Robert M. Bauer, Reg. No. 34,487, my attorneys; of ANTONELLI, TERRY, STOUT & KRAUS, LLP with offices located at 1300 North Seventeenth Street, Suite 1800, Arlington, Virginia 22209, telephone: (703) 312-6600, fax: (703) 312-6666; with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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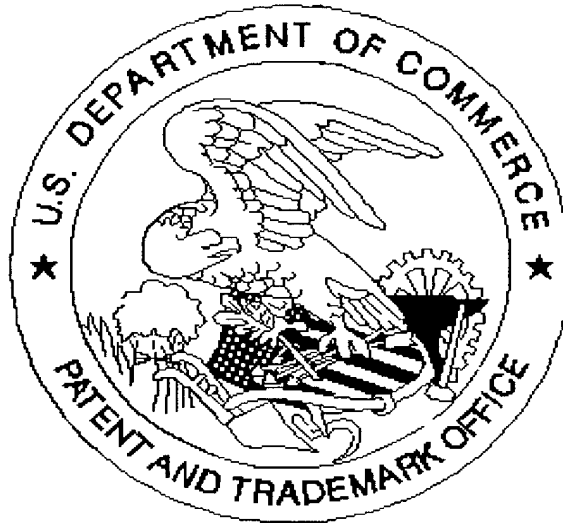
Full Name of Second/Joint Inventor \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence \_\_\_\_\_ Citizenship \_\_\_\_\_  
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